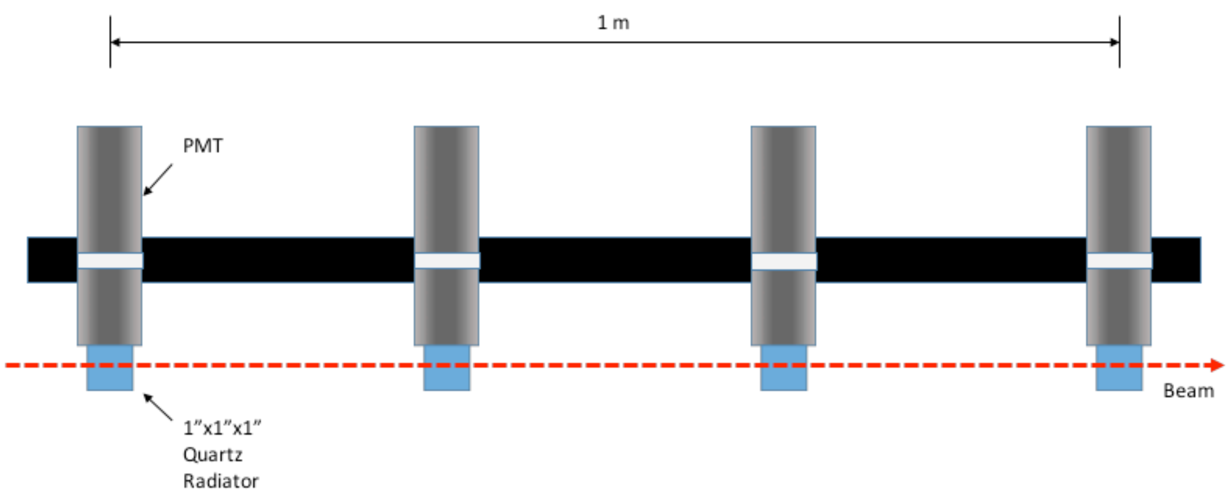
Fermilab

Directorate

TECHNICAL SCOPE OF WORK
FOR THE 2016 FERMILAB TEST BEAM FACILITY PROGRAM

T-1073

Precision Beam Timing Monitor



June 29, 2016

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I. Introduction

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of Fermilab, Northern Illinois University (NIU), Lewis University, and Purdue University, who have committed to participate in beam tests to be carried out during the 2015-2016 Fermilab Test Beam Facility program.

The TSW is intended primarily for the purpose of recording expectations for budget estimates and work allocations for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to modify this scope of work to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

This TSW fulfills Article 1 (facilities and scope of work) of the User Agreements signed (or still to be signed) by an authorized representative of each institution collaborating on this experiment.

Description of Detector and Tests:

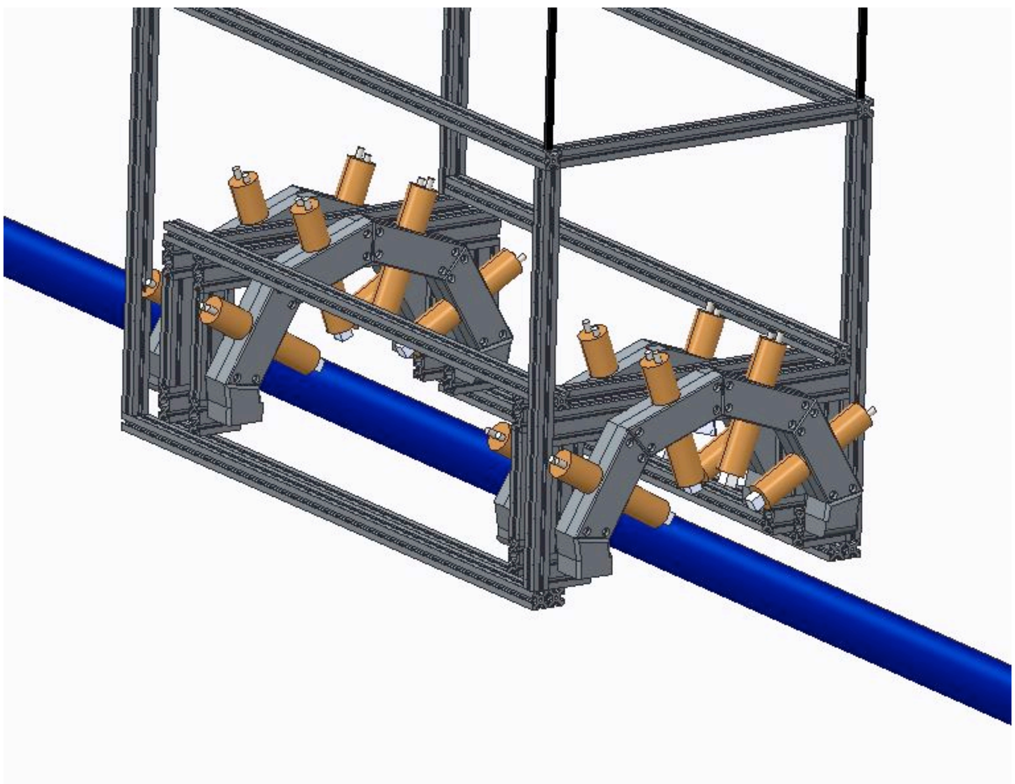


Figure 1: Precision Beam Timing Montor.

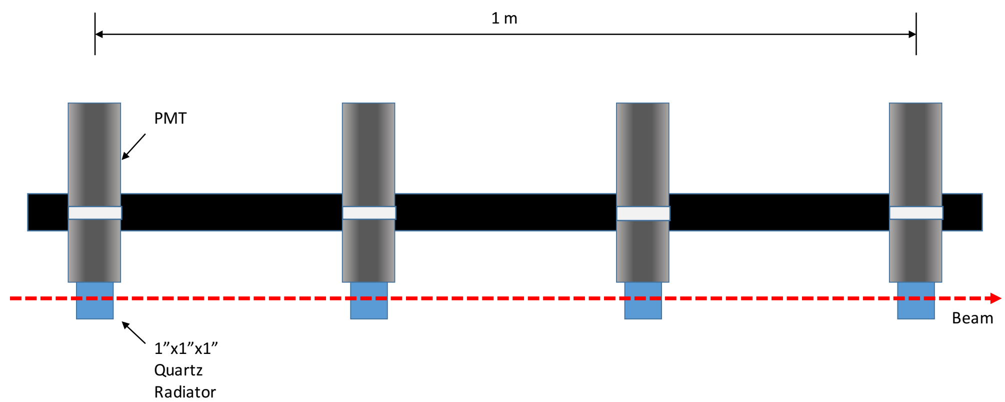


Figure 2: Single arm, to be tested at FTBF.

The purpose of this test is to evaluate the performance of one arm of the charged particle telescope described in the "Precision Beam Timing Monitor" LDRD proposal, which was funded for FY16 and FY17[1]. The full apparatus is shown in Figure 1. The purpose of the device is to use beam which has been scattered by a thin foil to integrate a statistical time profile of out-of-time beam with a sensitivity of 10^{-5} or better. The complete device consists of four arms, or "petals", each consisting of four radiators attached to photomultiplier tubes. It will be installed initially in the Recycler and will use the primary collimator as a scatterer.

The device is based on Quartz Cherenkov radiators, which were chosen because:

- They have a very fast response
- They don't suffer from the after-pulsing issues that scintillators have
- They are insensitive to soft backgrounds like neutrons and low energy pions, which can be an issue near intense beam lines.

The disadvantage is that the signal is significantly smaller than scintillators of a similar size, so it's important to verify the signals with a beam test.

The test device will consist of one arm of radiators and PMTs, as shown in Figure 2. In addition to verifying the signal from relativistic particles, this test will allow us to the commission the mTCA-based data acquisition system. This will save valuable time when the complete device is installed in the Recycler, where study time is very limited.

Our goal is to measure the response of the detector to highly relativistic protons.

I. Personnel and Institutions:

Spokesperson and person in charge of beam tests: Eric Prebys, Fermilab

Fermilab Experiment Liaison Officer: Mandy Rominsky

The group members at present are:

	Institution	Country	Collaborator	Rank/Position	Other Commitments
1.1	Fermilab	USA	Eric Prebys	Scientist II/AD	Mu2e, FAST/IOTA
			Peter Kasper	Scientist II/AD	Mu2e
			Andrei Gaponenko	Scientist I/PPD	Mu2e
			Rachel Margraf	Lee Teng Intern	
1.2	Northern Illinois University	USA	Dave Hedin	Professor	Mu2e
			Sergey Uzunyan	Research Scientist	Mu2e
			Sasha Dyshkant	Research Scientist	Mu2e
1.3	Purdue University	USA	Matthew Jones	Professor	CMS, Mu2e
1.4	Lewis University	USA	Ryan Hooper	Assistant Professor	Mu2e

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The beam test(s) will take place in the MT6.2 enclosure, on the 2C motion table.

2.1.2 In addition, space in the MTest control room will be needed for a data acquisition computer and limited work space for 2-5 people.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Energy of beam: 120 GeV and 1 GeV
Particles: Protons (120 GeV), pions, kaons, and muons (1 GeV)
Intensity: Maximum rate of the MTest primary proton line (~10^5 protons/spill)
Beam spot size: As small as possible

2.2.2 BEAM SHARING

Most of the time, these tests can run parasitically either upstream or downstream of other detectors.

If this detector is located upstream of other experiments, the Quartz radiators and trigger scintillators will introduce a total of roughly 1 radiation length of material.

The experiment can be place downstream of other experiments, provided they total on the order of one radiation length.

On the other hand, we plan to run some of the time with a Lead absorber in front of the detector, to generate showers. In these cases, we may put as much as 8" of Lead, which is equivalent to 1.2 interaction lengths or about 20 radiation lengths. This configuration is probably not compatible with downstream users; however, if this is an issue, we will promise to move the absorber out of the beam path outside of our primary running period each day.

2.2.3 RUNNING TIME

The experiment expects to run for 12 hours a day during day-time hours, (1000-2200). See section 2.3.3 for total run time and long-term schedule.

2.3 EXPERIMENTAL CONDITIONS

2.3.1 AREA INFRASTRUCTURE

The experimental apparatus is approximately 20cm x 20cm x 100cm. The total weight will be less than 10 kg. In addition, we will mount a maximum of four trigger paddles and PMTs on 80/20 supports, upstream and downstream of the detector. All of this will be secured to the movable table in area 6.2. We will require 10 HV and 10 signal patch panel channels through to the counting house.

For some runs, we plan to place a Lead brick upstream of the detector. This will have weight of 12 kg.

2.3.2 Electronics and Computing Needs

We will require 10 channels of negative high voltage capable of driving PMTs (at least 2.5 kV max). If this is not available, we will need rack space for a standard Fermilab bulk HV supply and divider module, which we will supply.

We will require a NIM crate, or rack space for a NIM crate for our trigger logic. We have adequate NIM electronics to build the trigger, so no PREP electronics are requested.

We require rack space for a standard μTCA crate which will house our data acquisition electronics.

We will require a local ethernet network, isolated from the main Fermilab network, such that we can connect electronic oscilloscopes or other devices that do not conform to Fermilab network security standards.

2.3.3 Description of Tests

Our general plan is to run from 1000-2200 each day. We require 6 hours to assemble the detector before we are ready for readiness inspection.

The goal of the tests is to measure the response of the detector under a variety of conditions. In particular, we would like to run with both 120 GeV primary protons and 1 GeV mixed secondary beam.

During the primary proton run, we plan to run at least two shifts with a Lead absorber of up to 8” upstream of the detector to generate high multiplicity showers.

We will perform frequency position scans for all configurations.

We do not anticipate frequent controlled accesses. Unless there are problems with the detector, we only plan to make accesses to insert, remove, or change the orientation of the upstream absorber.

2.4 Schedule

We plan to run for two weeks. The approximate schedule is:

- Week 1: 120 GeV primary protons
    - Last two days: Lead absorber upstream of detector
- Week 2: 1 GeV mixed beam

Experimental Planning Milestones

- June 1, 2016: Radiator/PMTs assembled and tested

- June 6, 2016: Data acquisition crate assembled and tested.
- June 29, 2016: Installation of detector and data acquisition crate.

III. RESPONSIBILITIES BY INSTITUTION – NON FERMILAB

3.1 NORTHERN ILLINOIS UNIVERSITY:

- Assembly, testing and mounting of radiator/PMT combinations

3.2 PURDUE UNIVERSITY:

- Assembly and programming of data acquisition crate.

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beamline as outlined in Section II. [0.25 FTE/week]
4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
4.1.3 Scalers and beam counter readouts will be made available via ACNET in the MTest control room.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to ACNET console and remote logging should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR). [0.25 FTE/week]
4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the neutrino flux by more than an amount set by the office of Program Planning, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION**:**

4.2.1 The test-beam efforts in this TSW will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab PPD DDO Test Beam Group will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and FTBF computers. [6.5 FTE/week]
4.2.2 No additional infrastructure or instrumentation needed.
4.2.3 No crane or forklift required.
4.2.4 Conduct a NEPA review of the experiment.
4.2.5 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.

4.2.6 Provide safety training as necessary, with assistance from the ESH&Q Section.
4.2.7 Update/create ITNA's for users on the experiment.
4.2.8 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews.

4.3 FERMILAB SCIENTIFIC COMPUTING DIVISION

4.3.1 Internet access should be continuously available in the MTest control room.
4.3.2 Si tracking system not needed
4.3.3 See Appendix II for summary of PREP equipment pool needs.
4.3.4 Configure private network [0.2 FTE]

4.4 FERMILAB ESH&Q SECTION

4.4.1 Assistance with safety reviews.
4.4.2 No sources required
4.4.3 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.2 FTE]

4.5 FERMILAB COLLABORATORS

4.5.1 Eric Prebys, AD

- LDRD principle investigator
- Experimental liaison
- 1 FTE-week

4.5.2 Peter Kasper, AD

- Setup and data taking
- .25 FTE-week

4.5.3 Andrei Gaponenko, PPD

- Setup and data taking
- .25 FTE-week

V. Summary of Costs

Source of Funds [$K]	**Materials & Services**	**Labor** (person-weeks)
Accelerator Division	0	1.5
Particle Physics Division	0.0	13.5
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	8.7
Totals Non-Fermilab	0.0K	4.0

6.1 GENERAL CONSIDERATIONS

6.2 THE RESPONSIBILITIES OF THE SPOKESPERSON AND THE PROCEDURES TO BE FOLLOWED BY EXPERIMENTERS ARE FOUND IN THE FERMILAB PUBLICATION "PROCEDURES FOR RESEARCHERS": (HTTP://WWW.FNAL.GOV/DIRECTORATE/PFX/PFX.PDF). THE SPOKESPERSON AGREES TO THOSE RESPONSIBILITIES AND TO ENSURE THAT THE EXPERIMENTERS ALL FOLLOW THE DESCRIBED PROCEDURES.

6.3 To carry out the experiment a number of Environmental, Safety and Health (ESH&Q) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The Spokesperson will follow those procedures in a timely manner, as well as any other requirements put forth by the Division's Safety Officer.

6.4 The Spokesperson will ensure at least one person is present at the Fermilab Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.5 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ESH&Q section.

6.6 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.7 The Spokesperson will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Scientific Computing Division management. The Spokesperson also undertakes to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Sector management.

6.8 The experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics listed in Appendix II. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.9 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.

6.10 The co-spokespersons are the official contact and are responsible for forwarding all pertinent information to the rest of the group, arranging for their training, and requesting ORC or any other necessary approvals for the experiment to run.

6.11 The co-spokesperson should ensure the appropriate people (which might be everyone on the experiment) sign up for the test beam emailing list.

6.12 The spokesperson, or designee, will generate a one-page summary of the experiment's use of the Test Beam facility during the fiscal year, to be included in the annual Test Beam Report Fermilab submits to the DOE.

At the completion of the experiment:

6.13 The Spokesperson is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Spokesperson will be required to furnish, in writing, an explanation for any non-return.

6.14 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ESH&Q requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

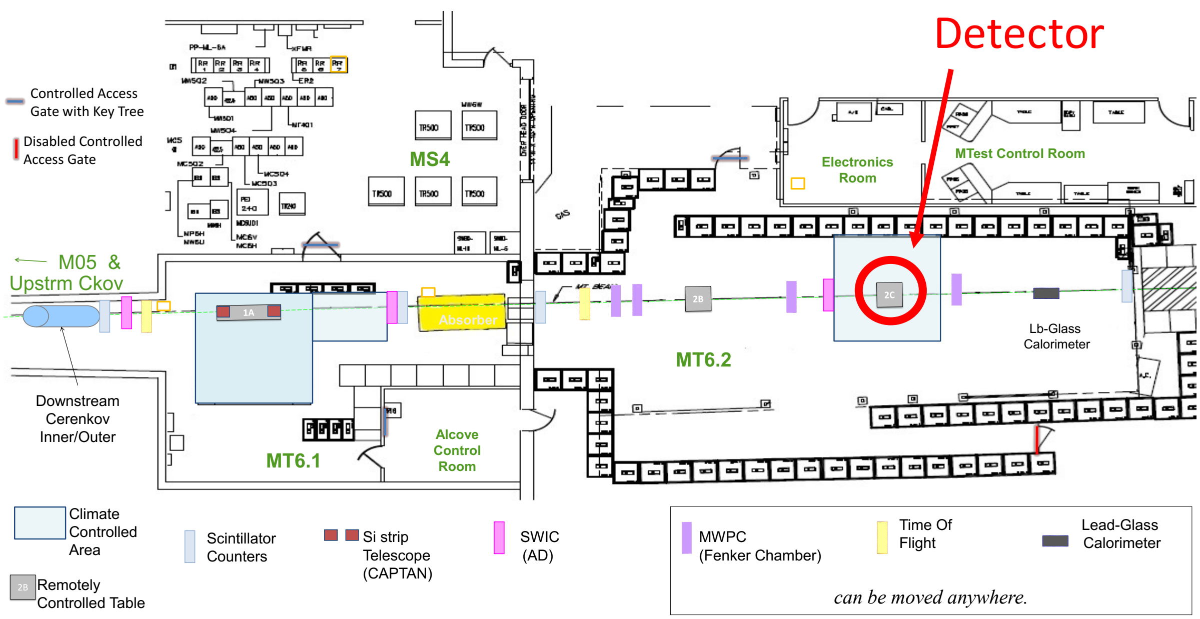
SIGNATURES:

______________________________________ / / 2016
Eric Prebys, Experiment Spokesperson

Appendix I: MT6 Area Layout

The apparatus will be located on the movable table, as indicated below.

MTest Areas



APPENDIX II: EQUIPMENT NEEDS

Provided by experimenters:

NIU: Assembled detector

Purdue University: Assembled data acquisition crate.

Equipment Pool and PPD items needed for Fermilab test beam, on the first day of setup.

PREP EQUIPMENT POOL:

Quantity	Description

PPD FTBF:

Quantity	Description

Appendix III: - Hazard Identification Checklist

Items for which there is anticipated need should be checked.
See ORC Guidelines for detailed descriptions of categories.

Flammables (Gases or Liquids)		**Gasses**		**Hazardous Chemicals**		**Other Hazardous /Toxic Materials**
Type:		Type:			Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:		Flow rate:			Hydrofluoric Acid	
Capacity:		Capacity:			Methane	
Radioactive Sources		**Target Materials**			photographic developers	
	Permanent Installation		Beryllium (Be)		PolyChlorinatedBiphenyls	
	Temporary Use		Lithium (Li)		Scintillation Oil	
Type:			Mercury (Hg)		TEA	
Strength:		X	Lead (Pb)		TMAE	
Lasers			Tungsten (W)		Other: Activated Water?	
	Permanent installation		Uranium (U)			
	Temporary installation		Other:	**Nuclear Materials**		
	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:			Capacitor Banks	**Mechanical Structures**		
Wattage:		X	High Voltage (50V)		Lifting Devices	
MFR Class:			Exposed Equipment over 50 V		Motion Controllers	
			Non-commercial/Non-PREP		Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:		Inside Diameter:			Beam line magnets	
Operating Pressure:		Operating Pressure:			Analysis magnets	
Window Material:		Window Material:			Target	
Window Thickness:		Window Thickness:			Bubble chamber	

The following people have read this TSW:

____ / / 2015
Patty McBride, Particle Physics Division, Fermilab

____ / / 2015
Sergei Nagaitsev, Accelerator Division, Fermilab

____ / / 2015
Martha Michels, ESH&Q Section, Fermilab

____ / / 2015
Robert Roser, Chief Information Officer, Fermilab

____ / / 2015
Joe Lykken, Chief Research Officer, Fermilab